DIAPERS FROM FLUFF KENAF

(DIAPER DARI FLUF KNAF)

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ABSTRACT

High quality fluff pulp can be made from long bast fiber of kenaf, which is separated from parenchyma cell and other substances by mechanical process. The separated fiber bundles of 2-3 m length need to be cut into 3-5 cm before pulping. In the present experiments, fluff pulp was prepared by the use of soda process with the following parameters: active alkali of 12%, 14% and 16%; liquor to solid ratio of 1:4; maximum temperature at 165 °C; and time to max temperature and time at max temperature was for 1.5 and 2 hours, respectively. An elementally chlorine free (ECF) bleaching with $OD_0ED_1D_2$ sequences was carried out to bleach the resulting pulp. Fluffing was done either in a willeymill or shredder with and without super absorbent polymer (SAP) treatment. Treatment with SAP was varied from 10-30%. It was found that yield and kappa number was in the range of 61.83–65.01% and 10–14, respectively. Other properties such as brightness, extractives content, viscosity, and knots was higher than 89 % GE, 0.01%, 4.76 cp, and 5 %, respectively. Absorbent capacity of kenaf pulp in the present experiment was ranged from 7.03-18.78 g/g. It is dependent on the active alkali, SAP concentration and methods of fluffing. Most of examined properties met the requirement of commercial diapers. SAP treatment was significantly increased absorbent capacity of the fluff pulp.

Key words: kenaf, fluff pulp, absorbency, SAP, ECF

ABSTRAK

Fluf pulp mutu tinggi dapat dibuat dari serat dari kenaf, yang dipisahkan dari sel parenchyma dan bahan-bahan lain secara proses mekanis. Gabungan serat terurai dengan 2-3 m perlu dipotong – potong menjadi 3-5 cm sebelum pembuburan. Penelitian saat ini, bubur fluff disiapkan dengan dengan menggunakan proses soda dengan parameter-parameter berikut: 12%, 14% dan 16% alkali aktif; perbandingan liquor terhadap padatan 1:4, suhu maksimum 165oC, dan waktu hingga suhu maksimum dan waktu pada suhu maksimum adalah masing-masing 1.5 dan 2 jam. Unsur khlor bebas yang dibleaching dengan urutan $OD_0ED_1D_2$ dilakukan untuk membleach pulp dihasilkan. Fluffing dilakukan dalam willeymill atau shreeder dengan atau tanpa perlakuan super absorbent polymer (SAP). Perlakuan dengan SAP divariasikan dari 10 – 30%. Hasil diperoleh menunjukkan yield dan bilangan kappa masing – masing dalam rentang 61.83-65.01% dan 10-14. Sifat-sifat lain seperti kecerahan, kandungan terekstrasi, viskositas dan knots berturur-turut lebih tinggi daripada 89% GE, 0.01%, 4.76 cP, dan 5%. Kapasitas dari bubur kenaf dalam percobaan berada dalam rentang 7.03 – 18.76 g/g. Hal ini bergantung pada alkali aktif, konsentrasi SAP dan metode fluffing. Seluruh sifat-sifat yang diuji memenuhi persyratan diaper komersial. Perlakuan dengan SAP meningkatkan kapasitas absorben dari bubur fluff secara nyata.

Kata kunci: *kenaf, fluff pulp, absorbency, SAP, ECF*

I. INTRODUCTION

Fluff pulp is usually bleached chemical, mechanical or chemimechanical pulp known also as fluffing or comminution pulp. It is mostly used for absorbent material in disposable diapers, bed pads, and hygienic personal products (Brunsvik 1987, Rismijana et al. 1992). Demand on fluff pulp is increasing due to the fast growing demand of natural absorbent material. Several decades ago world consumption of fluff pulp has reached over 2 million tons/year with a prediction of 0.5-1% annual growth rate (Brunsvik 1987). Indonesia alone, in the year of 2005 with hers 3.3 million children below three years has consumed 79.200 tons of fluff pulp, in which most of required fluff pulps for absorbent material are imported from Europe, United State and Australia. There is no existing mill of fluff and kenaf pulp in Indonesia. Therefore, opportunity to invest in fluff pulp industry in Indonesia is still promising. Lacking information on processing technology of kenaf might have been the cause of low interest in investment on kenaf pulp production. However, few investigations on kenaf have been carried out by the Center for Pulp and Paper in cooperation with Leces Pulp and Paper mill, and also by the Center for Research and Development of Tobacco and Fiber Plant of Indonesia. The results indicated that kenaf is very potential source of high quality fiber (Risdianto and Haroen 2004). In addition, these authors have noted that Australia and China have produced kenaf pulp for high quality commercial paper and it is more expensive than non bleached kraft pulp.

Fluff pulp must be low in extractive content, since extractive is hydrophobic and reduce the capability of pulp to absorb water (Field 1982). On the other hand, fluff pulp requires high cellulose content, low pulp viscosity, high content of long fiber and low primary fines content (Soderhjelm and Nordfeldt 1979), thus render pulp to absorb more liquid.

Cotton has been primarily the most preferred natural absorbent material for diaper and other hygienic products. Unfortunately, cotton is expensive and difficult to obtain. Other sources of hydrophilic natural material such as cellulose fiber (Gallary 1973) from wood and kenaf are potential to substitute cotton fibers. Most of wood based fluff pulps are currently derived from softwood. Its long fibers can generate fluff pulp with higher absorbency than that of short fiber (Field 1982). Many sources of non wood fiber have been also known to have long fibers, such as that of kenaf. It is a fast growing plant that can be harvested within 140-150 days (Mimms et al. 1993) and productivity of 2-2.5 tons (bd) per Ha (Kangiden et al. 1996). Furthermore, it has been reported to have a good prospect for fluff pulp, utilized in the preparation of jute bags, carpets and high quality non-woven (Risdianto and Haroen 2004). Tests have been also intensively carried out for kenaf sorbents to remove heavy metals, pesticides and oil in city run off water (Rowell and Stout 2007). Defiberization (fluffing) is prominent step for kenaf pulp to reached satisfying absorbency (Risdianto and Haroen 2004).

As for most of non wood fiber sources, kenaf fluff pulp production is best suited with soda process. This is due to its low lignin content and soda process is more environmentally friendly as well as more economical than that of superior kraft process (Risdianto and Haroen 2004). Even though kenaf can grow fast, problems such as sustainable plantation, fiber handling, storage and transportation remain to be solved. Once the problems are solved, fluff pulp from kenaf is expected to grow in the future.

The present experiment is intended to determine the properties of fluff pulp from kenaf based on a more environmentally friendly process.

II. MATERIALS AND METHODS

Figure 1 indicates the flow diagram of the present investigation. Kenaf stalk was chipped into 3-5 cm length followed by moisture content measurement. Soda pulping of the chips of kenaf was carried out in a 1600 grams (OD) capacity of rotary digester. Active alkali charges of the process was 12% (PK-12), 14% (PK-14) and 16% (PK-16) based on oven dry weight of chips with the liquid to wood ratio of 1:4. Total cooking time was set for 3.5 hours consist of impregnation time for 1.5 hours and time at maximum temperature (165 °C) for 2 hours. The resulting pulps were then screened and washed before bleaching process. Kappa number was measured after pulp washing in order to determine appropriate bleaching condition. Pulps were bleached following ECF bleaching methods with $OD_0ED_1D_2$ bleaching sequences. Table 1 indicates the conditions of bleaching process carried out in the present experiments.

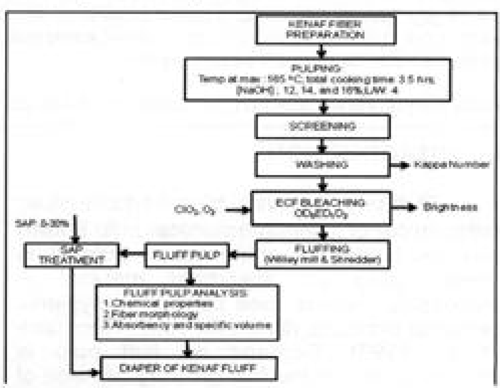

Figure 1. Diagram of the Present Investigation

Table 1. The Conditions of Bleaching Process for Fluff Pulp of Kenaf

Parameter	Stages of bleaching				
	O	D_0	E	D_1	D_2
Time (min)	60	60	60	180	180
Temperature (°C)	100	70	70	75	75
Pressure of O_2 (psi)	87	-	-	-	-
Consistency (%)	10	10	10	10	10
ClO_2, (%)	-	0.22 KN	-	1	0.5
NaOH (%)	1	-	2	-	-
$MgSO_4$, 7H2O (%)	0.5	-	-	-	-

a. O = Oxygen bleaching; E = Alkaline extraction with NaOH; D_0, D_1, and D_2 are initial, second, and third ClO_2 bleaching, respectively
b. *(%) active

III. RESULTS AND DISCUSSION

3.1 Pulping Properties.

Soda process was used to pulp kenaf chips in the present experiments. In this pulping system, hydroxyl anion from NaOH is the active species that reacts with lignin and other components of kenaf fibers (Mimms et al. 1993). The resulting pulp was then bleached with an ECF bleaching method following the sequences of $OD_0ED_1D_2$. Chlorine dioxide used in this ECF bleaching sequences is more environmentally benign with satisfying brightness and physical strength of the resulting pulp (Nakamata 2004).

Figure 2 indicates that lower screened yield and kappa number is achieved when using higher active alkali. In general high yield (above 60%) and low kappa number (below 15) were resulted from the current pulping of kenaf chips. It seems that all chips were well cooked in all level of alkali active. These are indicated by negligible percentage of rejects.

Kappa number indicates residual lignin in pulp (Casey 1980) and can be used to determine chemicals requirement in bleaching phase. The resulting kappa number from pulping with active alkali of 14% and 16% were insignificantly different. It was thought that at 14% alkali active the resulting pulp will have a high bleachability with satisfying fluff pulp quality.

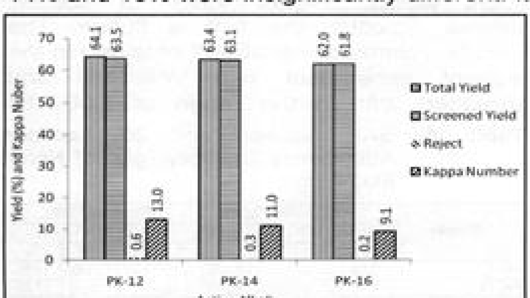

Figure 2. Yield and Kappa Number of Soda Kenaf Pulp.

Black liquor properties were also determined. Table 2 listed the values of total solid, pH, residual total and active alkali, organic and inorganic content of the resulting black liquor. Increasing active alkali clearly increased total solid of black liquor that reached 16.17% at 16% active alkali. Present total solid of black liquor was considered quite high compared to that normally of 9% for non-wood soda pulping process. Higher active alkali in cooking liquor resulted in lower residual active alkali, an indication of better chemical efficiency. This could be an indication of better swelling and liquor penetration with more alkaline pulping system. The lowest residual active alkali was found in cooking with 16% active alkali as shown by Table 2. In industrial scale, residual alkali is recovered and the organics are burned to produce energy (Mimms et al. 1993).

3.2 Chemical and Optical Properties of Pulp.

Lignin is hydrophobic substance that inhibits the pulp to absorb more liquid. Furthermore, lignin contains chromophoric group that darken the pulp. Thus, considering the use of the present pulp for commercial diaper, it is important for it to be free of lignin. An ECF bleaching method was employed to bleach the pulp. Table 3 indicates that the brightness of kenaf pulp bleached with $O\text{-}D_0\text{-}E\text{-}D_1\text{-}D_2$ sequences was reaching 89%, which is higher than that of Stora and commercial diaper fluff. Low

Table 2. Black Liquor Properties of Kenaf Pulping

Sample	Total Solids %	Residual		Organic	Inorganic	pH
		Total Alkali	Active Alkali			
PK-12	13.26	7.04	10.21	3.14	96.86	12.10
PK-14	14.54	8.25	9.20	3.68	96.32	12.12
PK-16	16.17	12.47	5.99	4.29	95.71	12.22

Table 3. Chemical Properties of Kenaf Fluff Pulp

Component	Fluff Pulp		Commercial Diapers
	Kenaf	Stora Fluff *	
Extractives, %	0.01- 0.07	0.15 - 0.30	0.1
α -cellulose, %	80.54-90.11	82.67- 86.87	85 - 90
Viscosity, cp	4.76	6.78- 6.87	-
Brightness, % ISO	89, 46	85-86	86
pH	6.5	6.0	-
Moisture content, %	9.2	8.0	-
AOX, kg/ton	0.05	< 0.1	-
Knot, %	5	- 8	-

*) Source: Stora Fluff EF, 1994.

extractives, low residual chlorine and high cellulose content (above 80%) are other important requirements of fluff pulp (Field 1982). As indicated by Table 3, all important requirements of fluff pulp from kenaf were better than these of Stora and commercial diapers. With the residual chlorine measured as AOX of less than 0.1, fluff pulp of kenaf is safe for hygienic products such as diaper. It will also function as a good absorbent material considering it high α-cellulose content.

3.3 Fiber Morphology of Kenaf Fluff.

Fiber length of kenaf was found in the range of 1.95-5.00 mm with the average of 2.98 mm. Classification of fiber length by Klemm (Casey 1980) put kenaf fiber in the class of long fiber (> 1.96 mm). It is comparable to the fiber length of Stora fluff and commercial diapers. Fiber length distribution of kenaf is indicated by Figure 3. Kenaf can be a primary choice for absorbent material due to its long fiber (>1.96 mm). Long fiber can provide high surface area, good interfiber bonding and high absorbency.

3.4 Absorbency of Kenaf Fluff Pulp.

The most important output of the fluff pulp production is its high liquid absorbency that can substitute imported fluff. Normally, dry cellulose fiber are hygroscopic that can absorb water from any source. However, cellulose can never be found a 100% dry. Extreme dryness can change the molecular structure of cellulose (Gallary 1973). Water absorption in the fluff pulp is classified into three ways by this author, i.e. water adsorption, water absorption, and capillary water

Water absorbency of kenaf fluff pulp is determined by the water present via hydrogen bonding with hydroxyl group of cellulose and water molecules trapped in the cavity of cellulose fibril system. The amount of water trapped in the cellulose fibril system is the maximum absorbent capacity of the cellulose (Field 1982, Soderhjelm 1979). Absorbency capacity of kenaf fluff from PK-14 and PK-16 found in the present experiment is comparable to that of Stora fluff and commercial diapers. Absorbency capacity of the pulp varied depends on fluffing methods (Willeymill vs. shredder). Absorbency of shredded fluff was higher than that of Willeymill fluff due to higher exposure of the shredded fluff. Willeymill fluff contains more fines and cut. Absorbency found in the present experiment was in the range of 7.03-9.20 g/g, which is close to 8.0–9.5 g/g of that of Stora fluff (0% SAP treatment at Table 4).

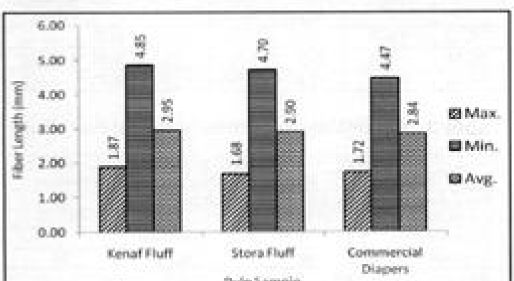

Figure 3. Fiber Length Distribution of Kenaf Fluff Pulp Compared to that of Commercial Fluff Pulp.

3.5 Absorbency Improvement by SAP Addition.

Super absorbent polymer (SAP) can improve the liquid absorbency of a material (Field 1982). Thus, in order to increase absorbency of kenaf fluff to a level comparable to that of commercial fluff, SAP with varied concentration was added to kenaf fluff. Table 4 indicates that a 10% SAP addition to kenaf fluff pulp from PK-12 increased its absorbency by 53%, i.e. from 7.03 g/g into 10.76 g/g. While a 30% SAP addition increased its absorbency up to 96%. The quantity of SAP addition must be properly determined due to its expensive price (Branon 1990, Visoli 1997).

3.6 Specific Volume of Kenaf Fluff Pulp.

Specific volume of fluff pulp indicates the ratio of a unit volume of fibers to a unit of fibers weight. Higher value of specific volume indicates the fluff is fluffier. The specific volume of kenaf fluff obtained in the present experiment (via Willeymill and shredder) was in the range of 5.80-7.84

Table 4. SAP Addition and 30 Seconds Absorbency Capacity (g/g) of Kenaf Fluff Pulp.

Sample	Willeymilled Fluff				Shredded Fluff			
	SAP (%)				SAP (%)			
	0	10	20	30	0	10	20	30
PK-12	7.03	10.76	11.98	13.78	9.05	12.17	13.08	14.90
PK-14	9.12	12.10	14.62	15.49	9.20	14.10	16.62	17.99
PK-16	9.11	13.63	15.07	16.42	9.03	14.63	16.47	18.78
Stora fluff	8.0 - 9.5							
Commercial Diaper	8.6 - 15.9							
100% SAP	25 - 30							

Tabel 5. Specific Volume (cm^3/g) of Kenaf Fluff Pulp

Sample	Willeymilled Fluff				Shredded Fluff			
	SAP, %				SAP, %			
	0	10	20	30	0	10	20	30
PK-12	5.80	6.20	6.82	6.97	7.24	7.58	7.69	7.73
PK-14	5.85	6.22	6.87	7.01	7.28	7.66	7.72	7.84
PK-16	5.80	6.27	6.85	6.98	7.27	7.64	7.74	7.81
Stora fluff	6 – 19							
Commercial Diapers	7.3-21.2							

cm^3/g. These values depend more on the method of defiberization process than on the cooking or bleaching processes. Table 5 indicates the values of fluff specific volume. The specific volume of fluff produce with Willeymill was lower than these of with shredder machine. This was due to more fine and soft in the Willeymill fluff and more voluminous fluff of shredder fluff. The fiber of fluff resulted from shredder was also coarser than these resulted from Willeymill. Specific volume affects the forming of network fiber tube, which will increase liquid absorbency when more tube is formed (Stora Enso 1994).

IV. CONCLUSIONS

Present experiments indicated that chemical properties of kenaf fluff mostly comparable to or even better than those of Stora fluff and commercial diapers. AOX content was very low, thus the fluff will be very safe and suitable for hygienic products such as diapers. Fluff pulp from kenaf was found to be in the class of long fiber.

Absorbency capacity of Willeymilled fluff was only comparable to those of the fluff of Stora and commercial diapers when produced from pulping process with 14 and 16% alkali active. However, with the addition of 10% SAP the absorbency capacity of all level of alkali active increased to the level of those of Stora and commercial diapers. While shredded fluff did not require any SAP addition to reach absorbency capacity of the fluff of Stora and commercial diapers. Similar finding was found with the fluff's specific volume.

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